REMARKS

Applicant has reviewed and considered the Office Action dated April 22, 2003 and the cited references therein. Claim 36 is canceled without prejudice or disclaimer; claims 2, 16, 20-22, and 37-40 are amended; new claims 41-44 are added. Claims 1-35 and 37-44 are pending in the present application.

The title and specification are amended to clarify the claimed invention.

Rejection of claims 1-4 and 13-15 under 35 U.S.C. 103(a)

Claims 1-4 and 13-15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kasanami et al. in view of Falangas and Triad Sentinel Article. Applicant respectfully traverses the rejection for the following reasons.

Claim 1 recites a system having a solid-state gyro with a single sheet of piezoelectric material forming a plurality of piezoelectric elements, capable of displaying gyroscopic navigational attitude information, direction information, and turn coordinate information simultaneously on a display.

Kasanami discloses a plurality of piezoelectric elements on a prismatic bender element for detecting rotational motion according to the Coriolis effect. More specifically, Kasanami discloses a vibratory gyroscope including a vibrating body having a polygonal section and piezoelectric elements. When a driving signal is applied to the piezoelectric element, the vibrating body makes bending vibration in the direction perpendicular to the main surface of the

piezoelectric element. Since the bending direction of the vibrating body and the main surfaces of the detecting piezoelectric elements are substantially at right angles relative to each other at rotation of the vibratory gyroscope, output voltages generated in the detecting piezoelectric elements are larger as compared with the prior art vibratory gyroscope (see column 2, lines 24-49). Kasanami states that it is simple to detect the rotational angular velocity in its vibratory gyroscope. Accordingly, Kasanami discloses a conventional vibratory gyroscope. Kasanami does not disclose or teach a solid-state gyro with a single sheet of piezoelectric material forming a plurality of piezoelectric elements as recited in claim 1. The advantages of the claimed solid-state gyro with a single sheet of piezoelectric material forming a plurality of piezoelectric elements are detailed on page 9, line 15 to page 10, line 18. Kasanami's system does not provide or appreciate these advantages.

Falangas discloses a general control system that uses piezoelectric elements for improving vibration isolation and directional control. More particularly, Falangas discloses that a set of conventional piezoelectric actuators (PZTs) 20a-f are bonded on two opposite sides of a S-bracket 10 (see column 5, lines 32-38; column 6, lines 1-4; and Fig. 1). Falangas also fails to disclose or teach a solid-state gyro with a single sheet of piezoelectric material forming a plurality of piezoelectric elements as recited in claim 1.

The Triad Sentinel Article is a preliminary product overview which announces that the Assignee of the present application has developed a solid-state, high-performance rotational rate sensor (gyroscope), the heart of an emergency navigation system designed for small aircraft. The Article does not disclose or teach in any details how to make or use a solid-state gyro. Further, the Article does not disclose or teach a solid-state gyro with a single sheet of piezoelectric material forming a plurality of piezoelectric elements as recited in claim 1, and

more importantly, how to make and use the solid-state gyro with a single sheet of piezoelectric material forming a plurality of piezoelectric elements. Accordingly, the combination of Kasanami's conventional piezoelectric vibrator, Falangas' conventional piezoelectric actuators and the Article does not result in the recited system having a solid-state gyro with a single sheet of piezoelectric material forming a plurality of piezoelectric elements. Therefore, Applicant respectfully submits that claim 1 patentably distinguishes over the cited references.

Claim 2 now recites a gyroscopic navigation system including first and second sensor modules for providing rotational rate signals and compensation signals, respectively, a microcontroller module for processing the rotational rate and compensation signals and generating attitude, directional and turn coordinate information, and a display for displaying the attitude, directional, and turn coordinate information simultaneously.

Kasanami discloses that its vibratory gyroscope includes a vibrating body having a polygonal section and piezoelectric elements. As discussed above, when a driving signal is applied to the piezoelectric element, the vibrating body makes bending vibration in the direction perpendicular to the main surface of the piezoelectric element. Since the bending direction of the vibrating body and the main surfaces of the detecting piezoelectric elements are substantially at right angles relative to each other at rotation of the vibratory gyroscope, output voltages generated in the detecting piezoelectric elements are larger as compared with the prior art vibratory gyroscope (see column 2, lines 24-49). Kasanami states that it is simple to detect the rotational angular velocity in its vibratory gyroscope. However, nowhere in Kasanami does it disclose or teach generating turn coordinate information. Falangas also fails to disclose a system having sensor modules and microcontroller module for generating attitude, directional, and turn coordinate information. The Triad Sentinel Article does not disclose or teach in any details of a

system having sensor modules and microcontroller module for generating attitude, directional, and turn coordinate information, and most importantly how to make and use a system having sensor modules and microcontroller module for generating attitude, directional, and turn coordinate information. Accordingly, the combination of Kasanami, Falangas, and the Article does not result in the system recited in claim 2. Therefore, Applicant respectfully submits that claim 2 patentably distinguishes over the cited references.

Claims 3-4 and 13-15, which are dependent from claim 2, are also patentable over the cited references for at least the same reasons above. Applicant further notes that the Examiner would allow claims 5-12 as they contain allowable subject matter.

Rejection of claim 23 under 35 U.S.C. 103(a)

Claim 23 is rejected under 35 U.S.C. 103(a) as being unpatentable over Triad Sentinel Article. Applicant respectfully traverses the rejection for the following reasons.

Claim 23 recites an aircraft instrument system having a plurality of aircraft primary instruments, a standby gyroscopic navigation system, and electric power for supplying power to the primary instruments and the standby gyroscopic navigation system.

As discussed above, the Triad Sentinel Article is a preliminary product overview which announces that the Assignee of the present application has developed a standby solid-state, high-performance rotational rate sensor (gyroscope), the heart of an emergency navigation system designed for small aircraft. The Article does not disclose or teach in any details how to make or

use a standby gyroscopic navigation system, nor does it disclose or teach how to make or use an aircraft instrument system with a standby gyroscopic navigation system as recited in claim 23.

Thus, Applicant respectfully submits that claim 23 is patentable over the Triad Sentinel Article.

Rejection of claims 24-26 and 35 under 35 U.S.C. 103(a)

Claim 24-26 and 35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Triad Sentinel Article in view of Kasanami et al. and Falangas. Claims 24-26 and 35 are dependent on claim 23. Applicant respectfully traverses the rejection for at least the same reasons discussed above and respectfully submits that claims 24-26 and 35 are patentable. Applicant also notes that the Examiner would allow claims 27-34 as they contain allowable subject matter.

Rejection of claim 36 under 35 U.S.C. 103(a)

Claim 36 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kasanami et al. in view of Burdess. Claim 36 is now canceled, and, therefore, the rejection is moot.

Rejection of claims 37-39 under 35 U.S.C. 103(a)

Claim 37-39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kasanami et al. Applicant respectfully traverses the rejection for the following reasons.

Claim 37 now recites a solid-state device having a plurality of sensors on a single multi-sensor chip, each sensor comprising the features recited in claim 16. As disclosed in the present invention (see page 7, lines 3-11), the advantages of configuring a plurality of gyro sensors on a multi-sensor semiconductor chip are that the sensors are matched and behave in a similar manner to extraneous forces or effects. Further, at a system or sub-system level, the sensors are capable of accurately compensating secondary phenomena, such as vibration, temperature, etc. Kasanami discloses a vibrator including a triangular prism shaped vibrating body. Piezoelectric elements are formed on each of the three side faces of the vibrating body. Accordingly, Kasanami not only does not disclose or teach configuring a plurality of sensors on a single multi-sensor semiconductor chip, but also has never addressed or appreciated the above advantages of configuring the sensors on a multi-sensor semiconductor chip. Thus, Applicant respectfully submits that claim 37 patentably distinguishes over Kasanami.

Claims 38-39, which are dependent from claim 37, are also patentable over Kasanami for at least the same reasons above.

Applicant has noted that claims 16-22 have been allowed by the Examiner.

Claims 16, 20-22, and 38-40 are hereby further amended to conform with the formality requirement.

In view of the above, it is respectfully submitted that the present application is in condition for allowance. Reconsideration of the present application and a favorable response are respectfully requested.

If a telephone interview would be helpful in resolving any remaining issues, please contact the undersigned at 612-752-7367.

Respectfully submitted,

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Date: July 16, 2003

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Markup Version of the Amendments

IN THE TITLE

Please amend the title to be as follows:

PIEZOELECTRIC RATE SENSOR SYSTEM AND METHOD.

IN THE SPECIFICATION

On page 8, the third full paragraph is amended as follows:

With respect to the heart of the standby navigation system, i.e. the gyros, the system in accordance with the principles of the present invention includes a solid-state micro-gyroscope (or "gyro"). The gyro generates [a voltage] an electrical signal output proportional to rotational rate. The gyro utilizes a plurality of precision thin-film piezoelectric elements to detect rotation, such as pitch, roll, and yaw, while rejecting spurious noise created by vibration, thermal gradients, and electro-magnetic interference. During a normal operation, selected piezoelectric elements on the gyro are driven by a periodic signal to create a controlled mechanical oscillation. When the gyro is subjected to rotational motion, such as pitch, roll, or yaw, a characteristic [voltage] electrical signal is produced across other piezoelectric elements on the gyro, according to the Coriolis Effect. These [voltages] electrical signals are amplified and filtered to extract high-fidelity signals proportional to the rate of rotation.

On page 17, the first full paragraph is amended as follows:

The first sensor module 122 includes a plurality of rotational rate sensors or micro gyros 136. One of the sensors 136 is for a directional gyro 132, and the other one is for an attitude gyro 130 (see Figure 3). A driver 134, e.g. an oscillator, provides oscillation signals to the rotational rate sensors 136 and receives feedback from a filter 160. The rotational rate sensors 136 provide rotational rates for pitch, roll, and yaw angles of an aircraft. The output [voltage] <u>electrical</u> signals of the rotational rate sensors 136 are proportional to the rate of rotation in the pitch, roll, and yaw directions.

On page 17, the second full paragraph is amended as follows:

The second sensor module 124 includes a plurality of compensation sensors. One of the compensation sensors is a temperature sensor 140. Another compensation sensor is a DC accelerometer 142 for measuring acceleration, vibration, or gravitational force. A third compensation sensor is a magnetometer 144 for measuring the magnitude and direction of a magnetic field. The compensation sensors provide acceleration, magnetic field, and temperature compensation signals. The output [voltage] <u>electrical</u> signals of the compensation sensors are proportional to low-frequency linear (i.e. DC) acceleration, temperature, and magnetic heading. It is appreciated that the compensation sensors, such as magnetometer 144, may be placed outside of the housing of the system 100. For example, an out-board magnetometer may be

placed at the rear end of an aircraft. Similarly, it is appreciated that in Figures 2 and 3, other components of the system 100 may be placed outside of the housing of the system 100.

On page 18, the first full paragraph is amended as follows:

An analog-digital converter (ADC) 138 converts the output [voltage] electrical signals from the gyro sensors 136 and compensation sensors 140, 142, 144 into digital signals and sends the information to a microcontroller 126 for data processing.

On page 26, the first full paragraph is amended as follows:

In addition, an identical mirror-image pair is located on opposite side of the proof-mass 168 (i.e. X1/X2 and X3/X4). During operation, these quad pairs (2X2) generate [voltages] electrical signals associated with motion along a particular coordinate axis. The differential nature and symmetric placement along the coordinate axes allows motion in other directions to be rejected, thereby increasing the signal accuracy. The amount of "off-axis rejection" is largely contributed by the symmetry of the pairs, matching of the elements, and precision placement. Such arrangement reduces the systematic drift and random noise normally present in a rotational rate sensor, thereby dramatically improving the performance of the system 100.

IN THE CLAIMS

Please cancel claim 36 without prejudice or disclaimer.

Please amend claims 2, 16, 20-22, and 37-40 are amended as follows:

2. (Once Amended) A gyroscopic navigation system, comprising:

a first sensor module, having a plurality of electrical rotational rate sensors, for providing a plurality of rotational rate signals;

a second sensor module, having a plurality of electrical compensation sensors, for providing a plurality of compensation signals;

a microcontroller module, coupled to the first and second sensor modules, for processing the rotational rate signals and the compensation signals and generating attitude information, directional information, and turn coordinate information; and

a display, coupled to the microcontroller module, for displaying the attitude information, the directional information, and the turn coordinate information simultaneously.

16. (Once Amended) A solid-state gyro, comprising:

a substrate having a proof-mass;

a membrane, the proof-mass being suspended on the membrane;

a single common electrode layer being disposed on the membrane;

[the] a single sheet of piezoelectric material being disposed on the single common electrode layer; and

a plurality of electrodes being disposed on the single sheet of piezoelectric material, [the] rotational rate signals being outputted through the electrodes, wherein each of the electrodes, the piezoelectric material, and the single common electrode layer form a plurality of piezoelectric elements.

20. (Once Amended) The [system] <u>gyro</u> of claim 16, wherein the piezoelectric elements are arranged and configured in an oval shape with a plurality of pairs of piezoelectric elements, one element in a pair is disposed on an inner ring of the oval shape, and the other element in the pair is disposed on an outer ring of the oval shape.

21. (Once Amended) The [system] <u>gyro</u> of claim 20, wherein the two elements of the pair have equal area.

22. (Once Amended) The [system] <u>gyro</u> of claim 20, wherein each pair of piezoelectric elements has a mirror image pair of piezoelectric elements disposed on opposite side of an axis passing through a center of the proof-mass.

37. (Once Amended) A [gyroscopic navigation system configuring a plurality of sensors on a single multi-sensor chip, capable of displaying gyroscopic navigational information on a display] <u>solid-state device having a plurality of sensors on a single multi-sensor chip, each sensor comprising:</u>

<u>a substrate having a proof-mass;</u>

<u>a membrane, the proof-mass being suspended on the membrane;</u>

<u>a single common electrode layer being disposed on the membrane;</u>

<u>a single sheet of piezoelectric material being disposed on the single common electrode layer;</u>

<u>a plurality of electrodes being disposed on the single sheet of piezoelectric material, sensor signals being outputted through the electrodes, wherein each of the electrodes, the piezoelectric material, and the single common electrode layer form a plurality of piezoelectric elements; and</u>

wherein the plurality of sensors share the substrate.

38. (Once Amended) The [system] device of claim 37, wherein the sensors include a solid-state gyro and a compensation sensor with shared lower electrode layer and shared piezoelectric layer.

39. (Once Amended) The [system] device of claim 37, wherein the sensors include a solid-state gyro and a compensation sensor with separate lower electrode layer and separate piezoelectric layer.

40. (Once Amended) The [system] device of claim 37, [wherein the system displays the gyroscopic navigational information, including attitude information, direction information, and turn coordinate information, simultaneously on the display] further comprising a gyroscopic navigation system capable of displaying gyroscopic navigational information on a display.

Please add new claims 41-44 as follows:

41. (New) A solid-state gyro with a thin-film of piezoelectric material forming a plurality of piezoelectric elements, wherein the piezoelectric elements output rotational rate signals.

42. (New) A method of displaying gyroscopic navigational information, comprising the steps of:

providing at least first and second sensors on a semiconductor chip, each of the sensors including a solid-state gyro with a thin-film of piezoelectric material;

providing a rotational rate signal by the first sensor;

providing a compensation signal by the second sensor;

processing the rotational rate signal and the compensation signal; and

generating the gyroscopic navigational information.

43. (New) The device of claim 37, wherein the sensors include a plurality of solid-state gyros with shared lower electrode layer and shared piezoelectric layer.

44. (New) The device of claim 37, wherein the sensors include a plurality of solid-state gyros with separate lower electrode layer and separate piezoelectric layer.